BUILDING PERFORMANCE

Practice Advisory 17: Well-planned ground investigations can save costs

The need for early site investigation is a key element in controlling costs of a project. This advisory describes the aims of site investigation, investment considerations and the site investigation strategy - including extent, depth and inherent uncertainties.

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Of interest to Building owners, Building consent authorities, Developers, Engineers, Architects

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Background

The Canterbury Earthquakes Royal Commission recommended that "A thorough and detailed geotechnical investigation of each building site, leading to development of a full site model, should be recognised as a key requirement for achieving good foundation performance". Evidence from the Canterbury earthquakes indicated that inadequate or inappropriate site investigations contributed to poor building performance. With increasing building activity in New Zealand, it is important to learn from this and encourage the practice of adequate and appropriate site investigations.

Turbine hall exposure.

Objective of site investigations

A ground investigation serves two primary purposes, by:

providing data for analysis and design

reducing uncertainty about ground conditions, thereby reducing the risk of construction cost variations.

The amount, location and method of ground investigation should be selected with both these aims in mind. The objective of a site investigation needs to be aligned with the project's requirements and the risks associated with unforeseen conditions or poor performance. The ground on which a building is built can be quite variable (refer to Figure 1). Ground conditions can vary with time, e.g. following earthquake, consolidation, weathering, deposition or erosion. This can pose real challenges in the design of a building and its foundations to withstand the potential impact of both existing conditions and the effects of natural hazards (such as earthquakes). Therefore, the objective of a site investigation is to gain a good understanding of:

- the geological makeup and history of the site (including the various subsurface soil layers and their properties, and groundwater conditions)
- the expected future behaviour of the site under a range of conditions, including seismic actions.

The understanding of site soil conditions is an essential input into robust foundation solutions.

Objectives

Do

- Use an appropriately qualified Geotechnical Professional (such as a Geotechnical CPEng or PEngGeol) to tailor the site investigation objective(s) to a project's requirements and risks.
- Recognise that site investigations are needed to gain a good understanding of the site's:
  - geological history
  - likely future behaviour
  - variability.

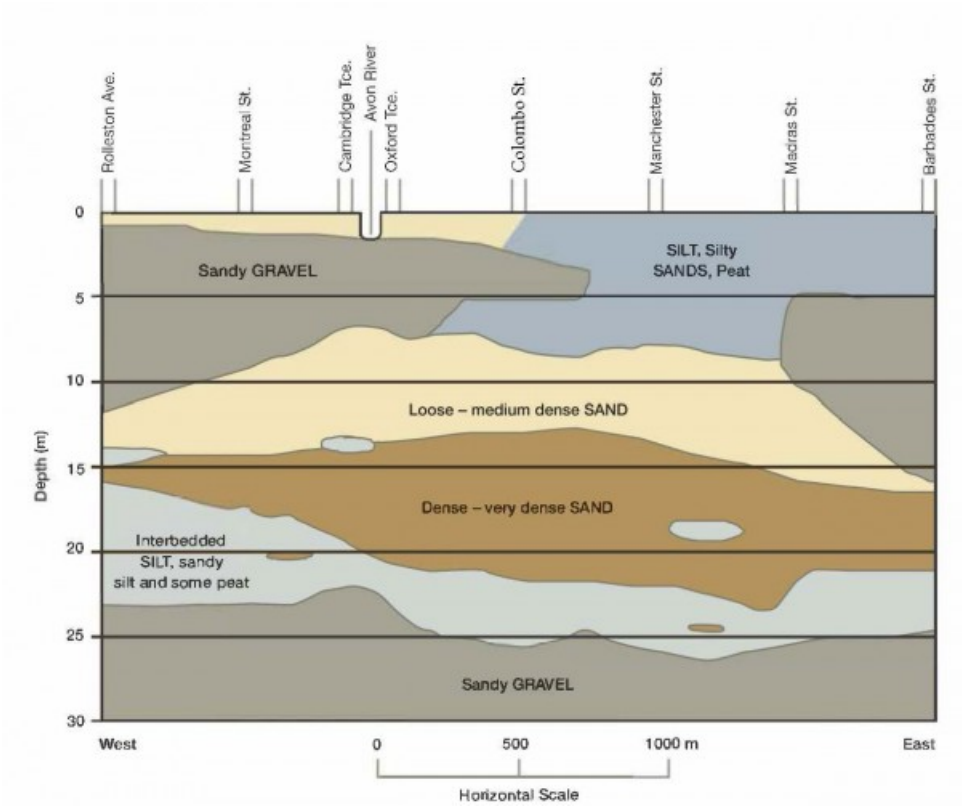

Figure 1: An example of a geotechnical site cross-section

Investment considerations

There can be tension between the desire of the geotechnical professional to perform technically optimised foundation design with more ground data through site investigations and the desire of the building owner or developer to minimise cost, particularly at the early stages of project development.

However, there is strong evidence of a direct correlation between a 'lowest cost' approach to ground investigations and very expensive project cost over-runs (Figure 2). An appropriately-scoped site investigation is usually a modest investment compared to the potential consequences of unsatisfactory ground performance. Appropriate site investigation can lead to construction cost savings. Conversely, under-investment in site investigations may lead to cost overruns and delays to projects at both the design and construction stages by failing to adequately identify ground issues. It can also result in post-development building performance issues.

Investment considerations

Do

- Perform an adequate level of site investigations.
- View site investigations as an investment capable of improving design, hence adding value to a project.
- Consider a specific site investigation programme in a project. It can be staged to reflect project development from concept to construction taking account of complexity of project.

Do not

- Underinvest in site investigations.
- Overlook site investigations costs in a project.

There is international evidence that a comprehensive site investigation can pay for itself many times over in reduced construction cost overruns.

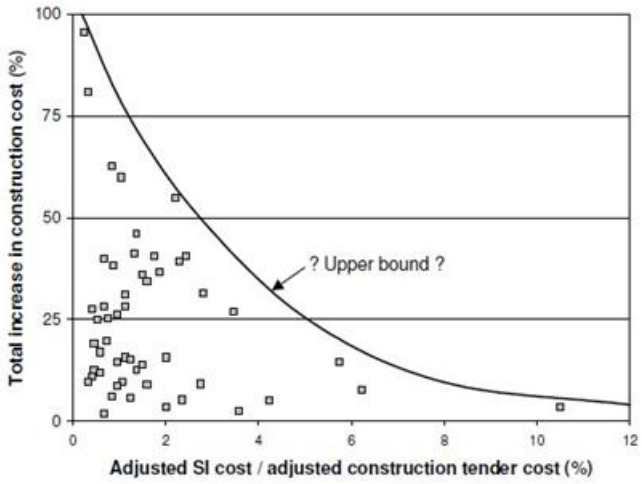

Figure 2: Impact of site investigation (SI) expenditure on UK highways contracts. From Mott MacDonald and Soil Mechanics, (1994).

When deciding on the scope and expenditure of a geotechnical site investigation, the knowledge of the site, the project objectives, complexity and risks all need to be considered.

Site investigation strategy

A site should not be considered in isolation, but in context with its surroundings, hazards and the landscapes of the area.

Depending on the particular characteristics of a project, it could involve, as a minimum, a non-intrusive desk study and a site walkover to develop a high-level understanding of the site. The desk study usually includes the collection of information from existing geological and hazard maps, published databases or documents, utility records, anecdotal evidence and aerial photographs.

This can then be followed by some or all of the following physical investigation works such as:

- trial pits
- boreholes
- penetration tests
- geophysical tests
- laboratory tests.

The investigation results are typically collated into a report. This may include interpretation of the data to inform the design process.

The site investigation strategy in areas of identified high ground-related risks (contaminated land, liquefiable soils, etc) should be closely communicated with the relevant authorities so that the objectives of investigations (for the project) meet or exceed legislative and consenting requirements.

Ground investigation is a risk assessment and management process, and, as such, is sometimes undertaken in an iterative manner. Risks are identified, investigated, and the outcome of these investigations determines the next steps. It should also be noted that additional investigation might be needed during design or construction as new risks are identified.

Strategy

Do

- Understand that a site's investigation strategy depends upon factors such as:
  - investigation objectives
  - site-specific conditions
  - project scale, complexity and sensitivity to ground performance
  - experience or judgement of geotechnical professional.
- Communicate site investigation strategies with relevant authorities so that legislative requirements are at least met or exceeded.
- Expect a phased investigation (typically starting with a desk study) to target and mitigate risks.

Do not

- Consider a site in isolation from its surroundings.

Extent and depth of site investigations

The geotechnical professional should determine the extent of a site investigation programme.

More information on site investigation of soils can be found in the MBIE-NZGS Guidance: Module 2 'Geotechnical investigation for earthquake engineering' of the 'Earthquake Geotechnical Engineering Practice' series document.

Module 2: Geotechnical investigations for earthquake engineering (https://www.building.govt.nz/building-code-compliance/b-stability/b1-structure/module-2-geotechnical-investigations/)

NZ Ground Investigation Specification (http://www.nzgs.org/library/nz-ground-investigation-specification/), a guide on procurement of site investigation, developed by Auckland Council, MBIE and New Zealand Geotechnical Society (NZGS) is also available on the NZGS website.

Extent and depth

Do

- Perform an appropriate level of site investigation which gives confidence to engineering designers to predict satisfactory performance of the site.
- Perform site investigations to depths that extend through all soil strata that might affect the building's performance.

Uncertainties in site investigations

It should be recognised that a site investigation programme samples at discrete points, and an interpretative model is then inferred from this data. Natural ground formation processes can lead to marked changes in subsurface location of soil strata over short distances. Therefore the actual ground stratigraphy may be different from that anticipated. It is recommended that the geotechnical professional be involved throughout the construction phase to check that design assumptions made are compatible with what is encountered on site during excavations

Given the above-mentioned uncertainties and limitations, it is recommended that all site investigations should be carried out under the supervision of an appropriately qualified geotechnical professional.

Site investigations where there are complex subsoil and ground water conditions, such as:

a. compressive soils
b. expansive soils
c. liquefaction-prone soils
d. organic soils
e. unstable soils

should be carried out by specialist geotechnical professionals with appropriate training and experience. Projects involving major bridges, dams, steep slopes, high retaining walls, natural hazards and multi-storey buildings with deep basements would likely require highly specialised geotechnical professionals.

Limitations

Do

- Recognise the inherent limitations and uncertainties of site investigation techniques.
- Understand that quality assurance and good practice are essential to produce credible ground data.
- Due to the uncertain and limited nature of ground engineering, engage an appropriately qualified geotechnical professional (i.e. Geotechnical CPEng or PEngGeol).

References

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